Shell Global Solutions

Shell Gas to Liquids in the context of a Future Fuel Strategy – Technical Marketing Aspects

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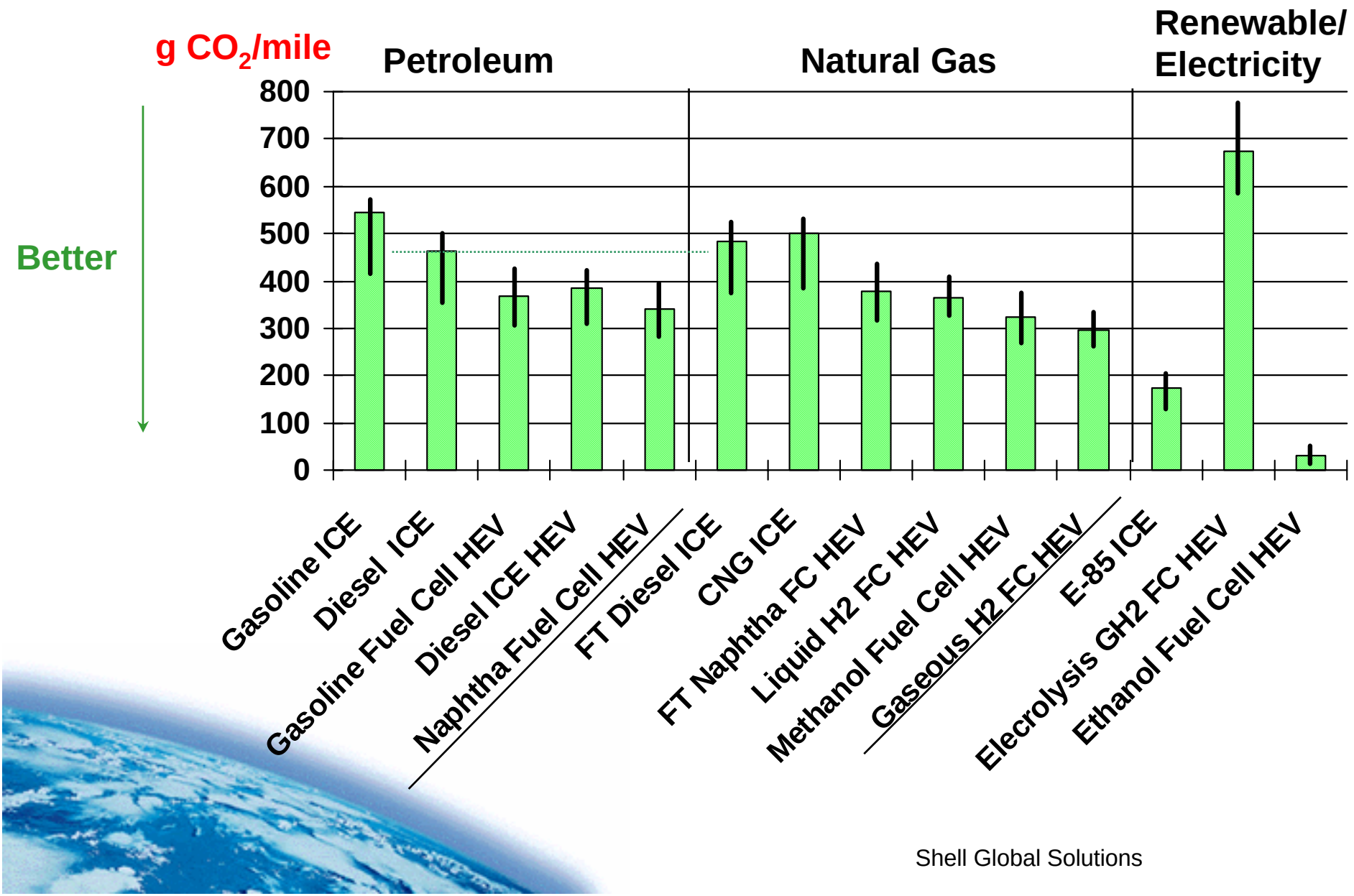
Talk Synopsis

- REQUIREMENTS OF A FUTURE FUEL STRATEGY
  - Sustainability challenges
  - Technology Drivers
  - Fuel Options
- GAS TO LIQUIDS
  - Advantages
  - Background studies
  - Pre-Marketing Activities - Stakeholders
  - Fleet trials
- CONCLUSIONS

Sustainability challenges

- Required to be met by any changes in transport fuels
- Need to balance the requirements of affordable mobility while reducing local and global environmental impacts
  - Cleaner Hydrocarbon Fuels enable more fuel efficient/low emission engine technology
  - Renewable Biofuels - e.g. ethanol and vegetable oil esters
  - Radical new technologies - e.g. Fuel cells & Hydrogen
- Alternatives need to meet economic and social sustainability criteria as well as contributing to environmental objectives
- Need to understand the challenge of consumer acceptance

Well-to-Wheel Greenhouse Gases - US Study



Technology Drivers

- First step is to extend availability of improved fuels which enable more efficient and lower emission engine technology

- Diesel direct injection
- Diesel particulate traps
- NOx traps
- SCR NOx reduction (selective catalytic reduction)
- DPNR (diesel particulate & NOx reduction)
- EGR
- Hybrid engines

- Gasoline direct injection
- 3 way catalysts (NOx, CO, HC)
- EGR (exhaust gas recirculation)
- De-NOx storage & reduction catalysts
- Hybrid engines

Fuels for the future

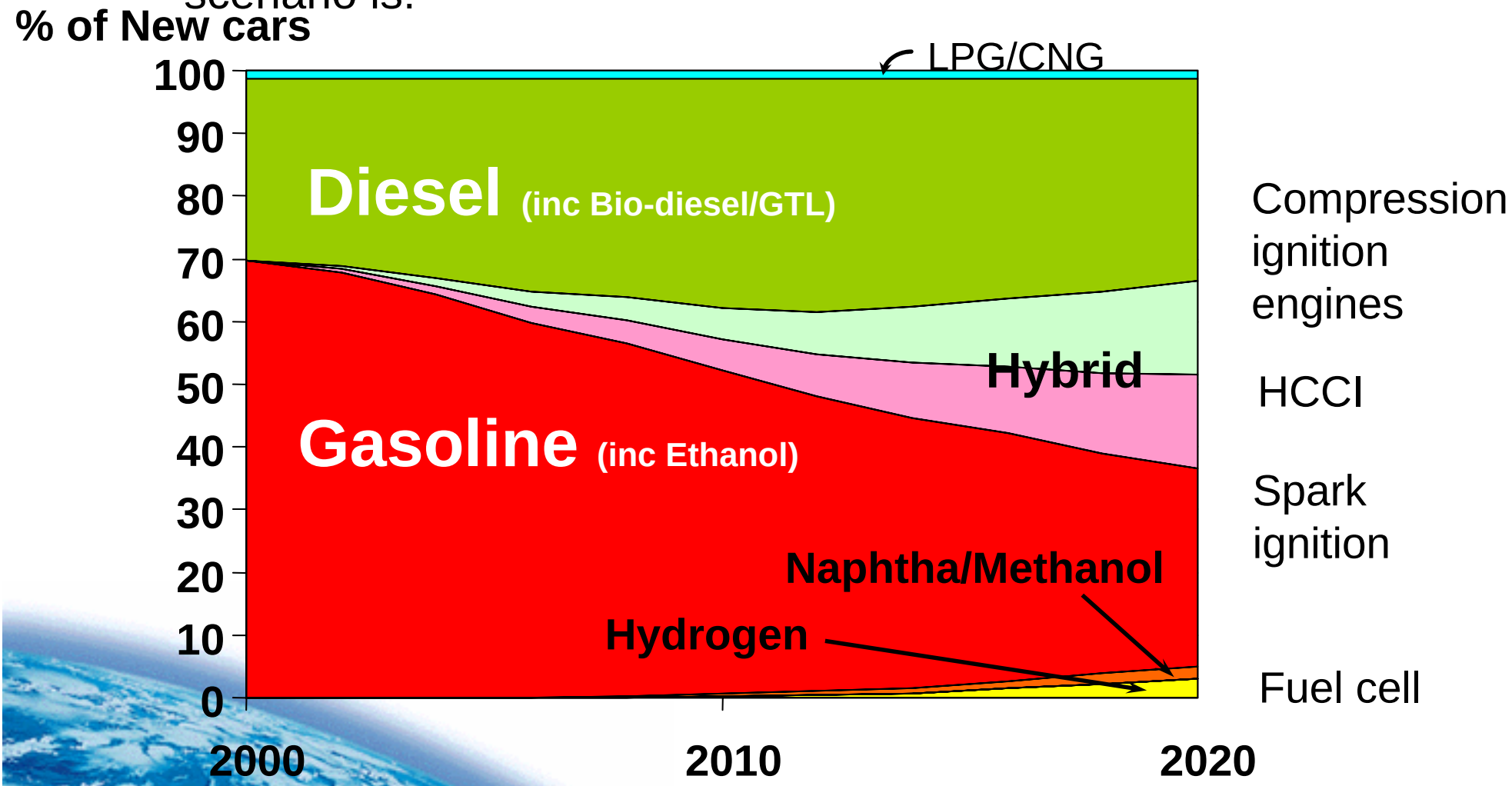
- Low S diesel
- Provision of Urea/Ammonia?

Fuels for the future

- Low S gasoline
- HCCI (homogeneous charge compression ignition) …new fuel types?

One view of the Future

- The next 20 years will see a wider range of technologies and fuel types, especially in the developed world……one possible scenario is:



Fuel Options – Bio-fuels, CNG, LPG & GTL

Bio-fuels

- Ethanol, ETBE (gasoline), Esters (Diesel)
- Can substitute oil imports & use agricultural surpluses, but practical limits on availability
- Use existing infrastructure
- Significant GHG reduction potential on WTW basis, but depends on production
- Cost 2-4 x conventional fuels, although still cheaper than some alternatives

CNG

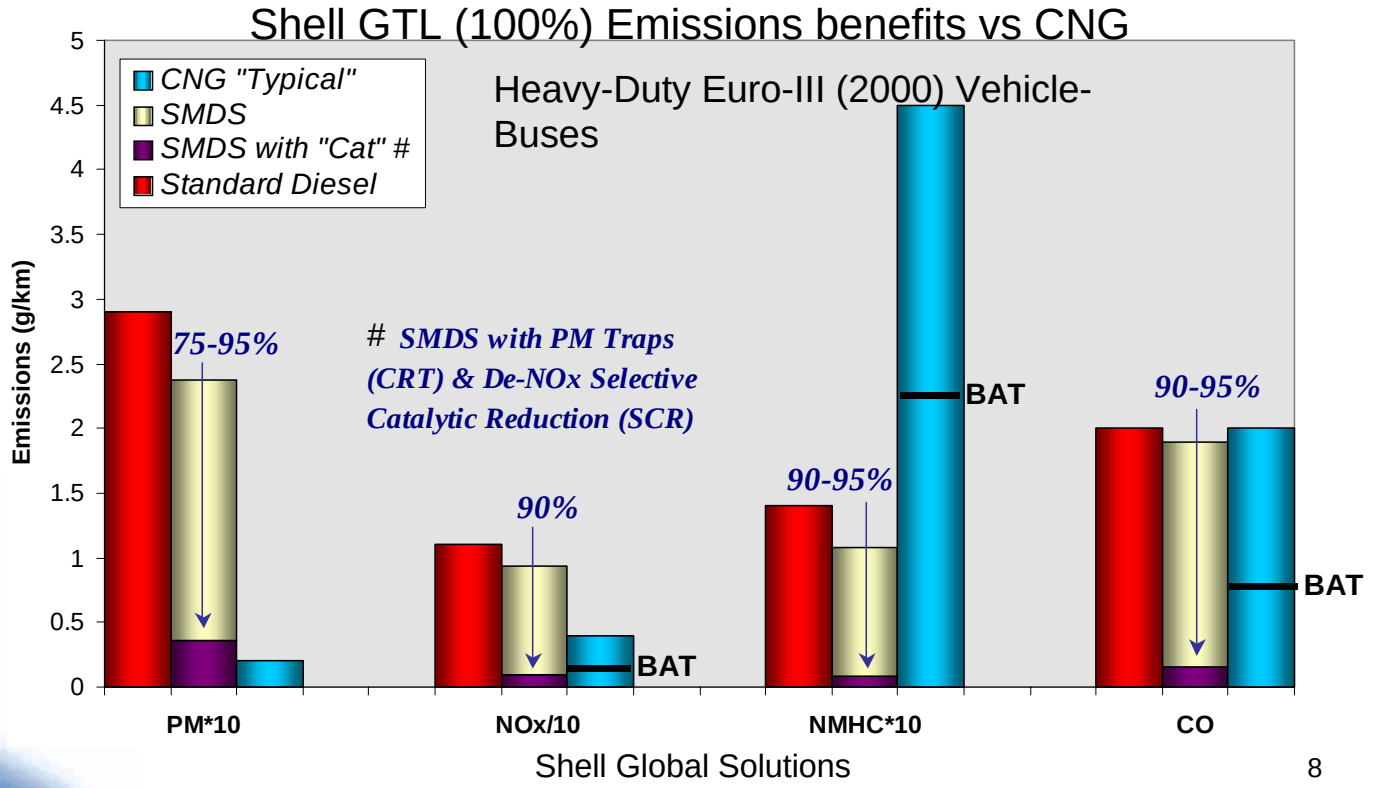
- Lower Sulphur, low PM, NOx & SOx
- Can substitute oil imports
- Expensive infrastructure
- Bulky on-board storage
- Shell companies assess locally whether to supply (eg. Argentina)

LPG

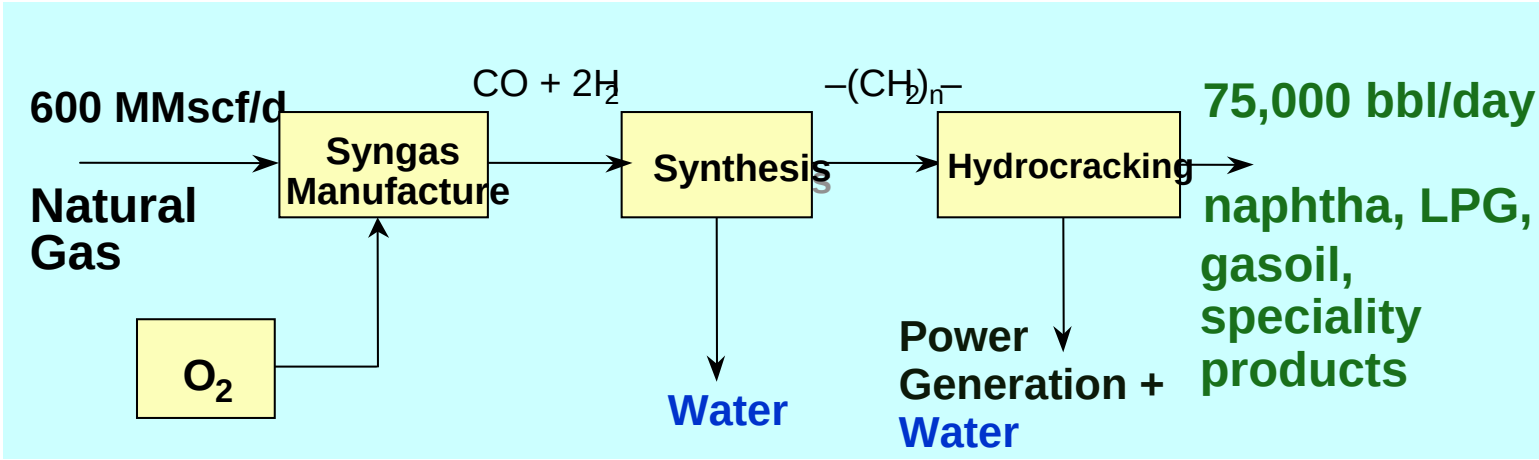
- Lower sulphur, PM, NOx and SOx
- Overall emissions similar to CNG
- Infrastructure costs lower than CNG
- Less bulky storage
- Supplied by Shell in many markets for both fleet and private motorist,

Fuel Options – Bio-fuels, CNG, LPG & GTL

- Alternatives such as CNG, LPG and GTL have a role in the future fuel mix, but unlike bio-fuels do not provide significant GHG benefits
- CNG, LPG and GTL have potential as niche fuels, especially where urban air quality is problematic
- GTL combined with appropriate engine technology would offer CNG type emissions benefits at lower overall cost



Shell Gas to Liquids –Process and Products



Commercially proven technology, at Bintulu, Malaysia since 1993 …..

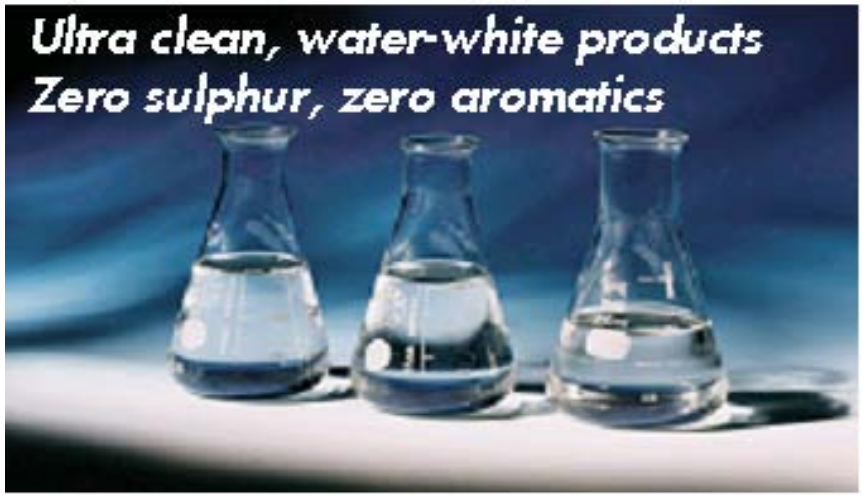
Gasoil product

- Odourless, low-toxicity, biodegradable, water-white
- Paraffinic
- Cetane 75-80
- Sulphur 0 ppm
- Density 780 Kg/m3
- Pour Point -18C*

*future Shell GTL plants

Advantages of GTL Automotive Gasoil

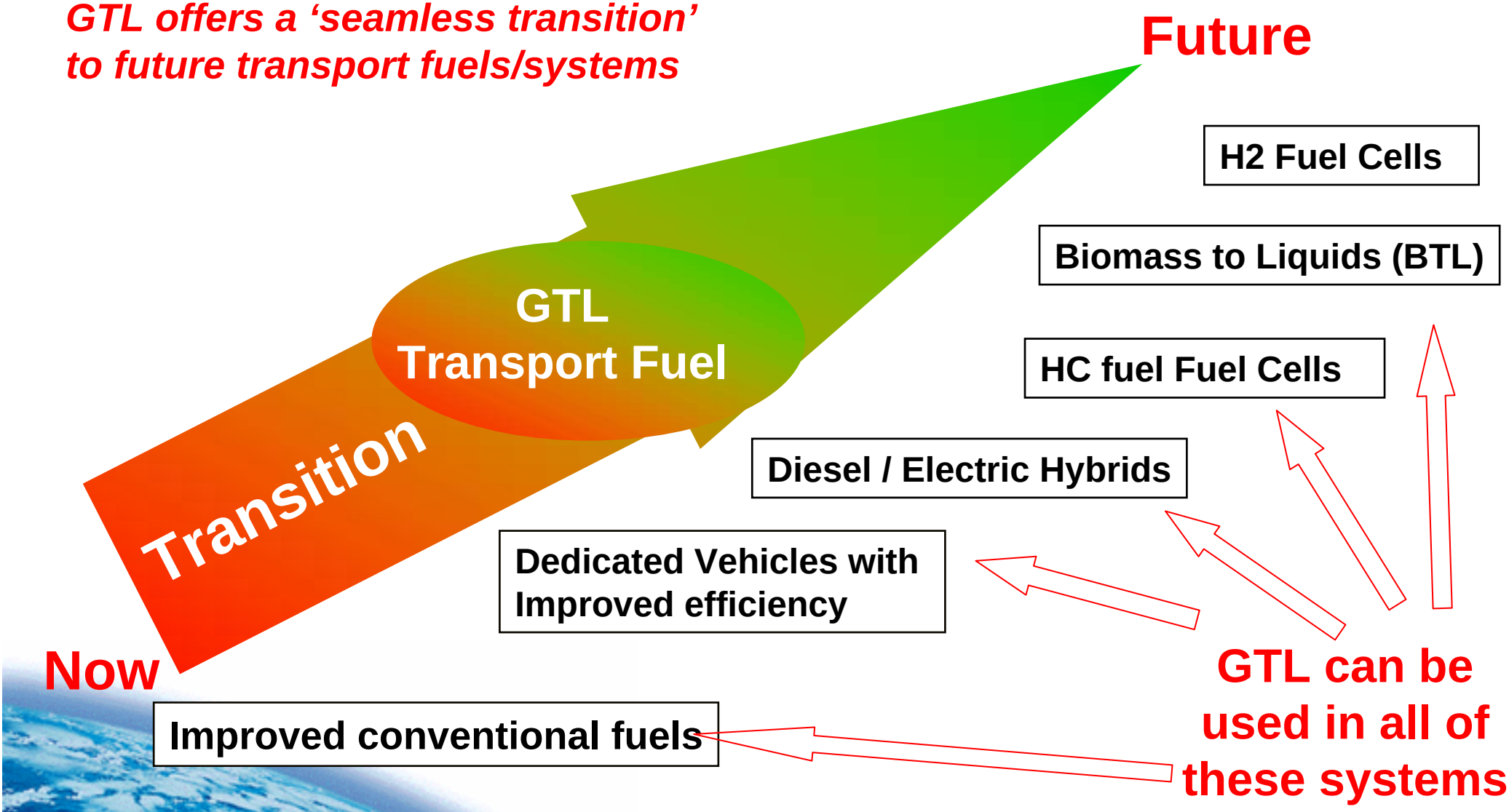
- Strategic diversification of energy supply - Gas-derived fuel
- Significant emissions benefits as a blend or 100%
- Compatible with existing diesel infrastructure



- Life cycle analysis (PWC), GTL vs. Refinery system (DEER2002 paper)
  - GTL, less impact on on air acidification and smog formation
  - No greater impact on global warming.
- "Future-Proof". Compatible with most conceivable directions of the fuels market
- More cost effective in reducing emissions than any competing fuel

Bridging the gap to Renewable Transportation Fuels

GTL offers a 'seamless transition' to future transport fuels/systems



Emissions Performance
-Current “on the road” technologies

We have a good idea of emissions benefits in current engine technology

Summarised %benefits for 100% Shell GTL

Benefit	Light-Duty			Heavy-Duty		
(%)	Euro I	Euro II	Euro III	Euro I	Euro II	Euro III
PM	42	39	41	18	18	34↔10
NOx	10	5	5	16	15	5↔19
HC	45	63	62	13	23	<9
CO	40	53	75	22	5	16

But….

Emissions Performance
-Future Challenges

- Developed world is rapidly moving towards “sulfur free” diesel
  - E.g. <15ppm or <10ppm S
  - Is there a benefit of GTL over other sulfur free systems ?
- Modern engine technologies with or without advanced aftertreatment are liable to make all fuels look similar
  - Does GTL still have an edge on emissions performance ?
- Research effort and collaborations to address these issues
  - Collaborations with VW and Bosch on light- and heavy duty engines
  - Shell commission work with AVL (Austria) in Euro-4 (2000) and Euro-5 (2005) prototype heavy duty engines

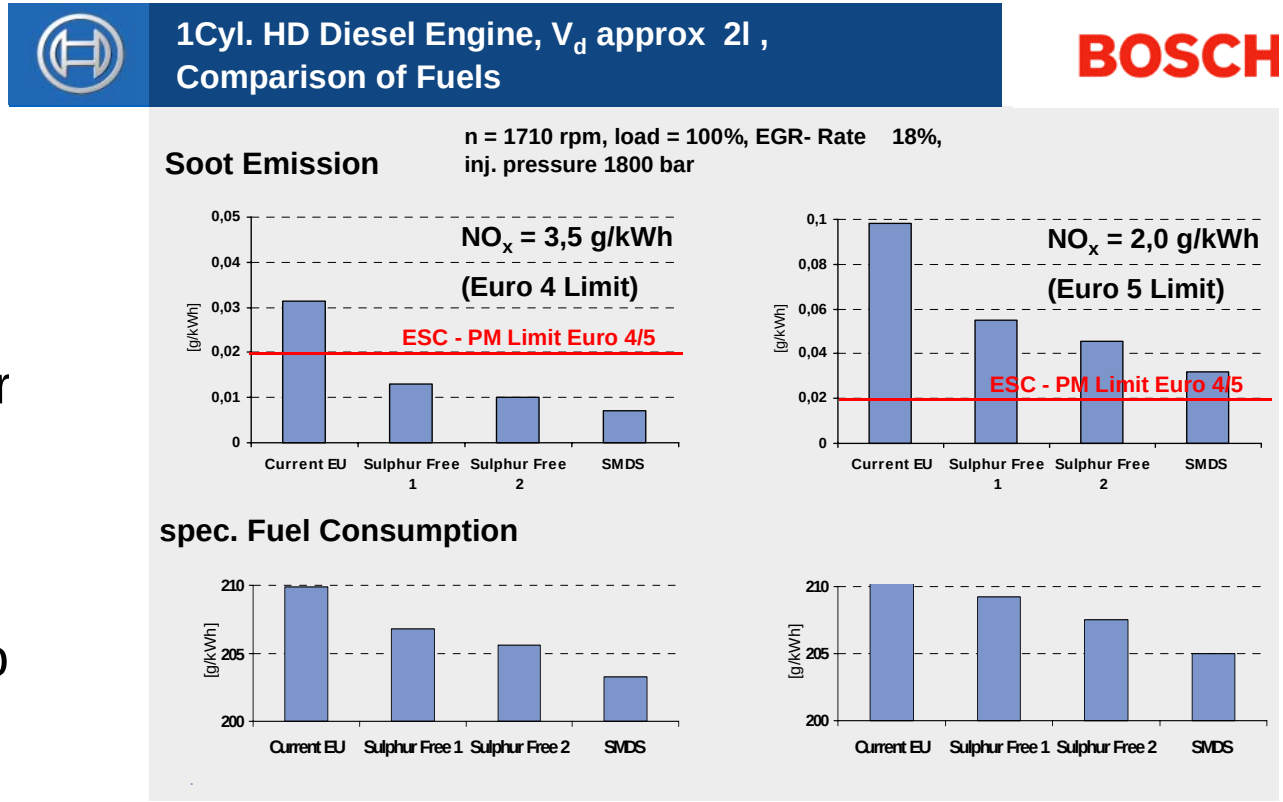
Emissions Performance – Collaborations with Bosch & VW

BOSCH-SHELL

- Bosch HD research engine configured to Euro-4 or Euro-5 NOx limits
- 100% GTL showed PM benefits against other sulfur free fuels

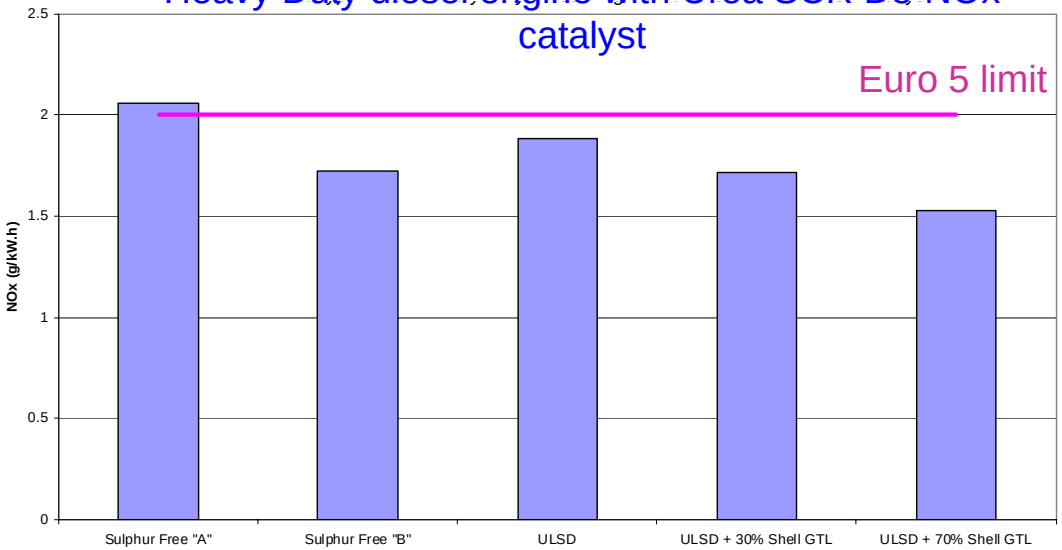
VW-SHELL

- Studies with prototype Euro 4 engines and cars with 100% GTL & EU standard diesel
- PM benefits of ~50%
  - i.e. better than in earlier technologies



Emissions Performance -Shell study at AVL

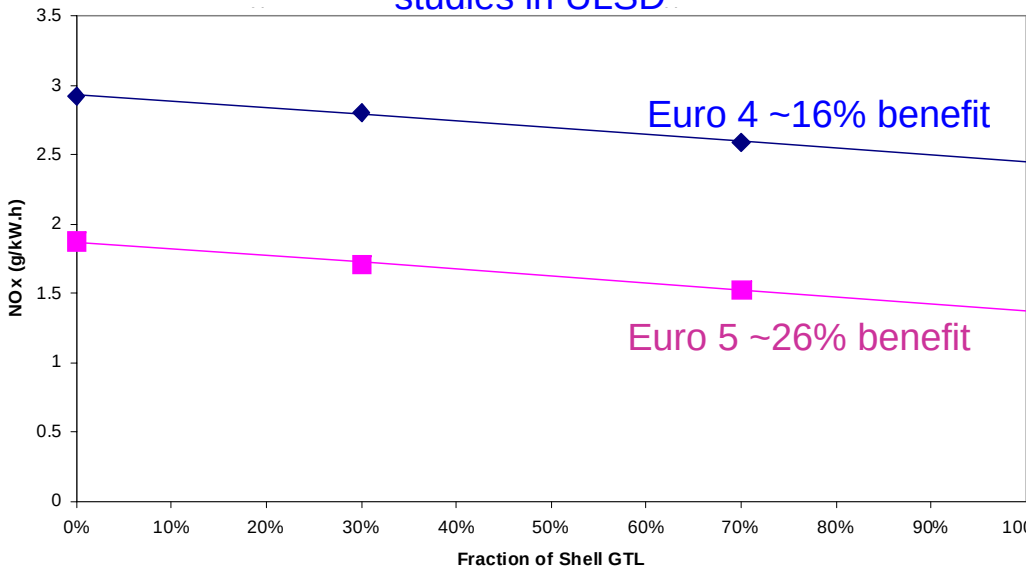
NOx emissions comparison from prototype Euro-5 Heavy Duty diesel engine with Urea SCR De-NOx catalyst



- Engines
  - Prototype Euro-4 (2005) engine with PM trap
  - Prototype Euro-5 (2005) engine with SCR deNOx
- Fuels
  - Blends of GTL in ULSD (50ppm S)
  - 2 sulfur free fuels (<10ppm S)

- Significant NOx benefits of GTL still seen in both advanced engine systems (Euro-4 and Euro-5)
- NOx benefits of GTL blends (30 & 70%) when compared to either ULSD of sulfur free fuels

Extrapolated NOx benefits of 100% GTL from blends studies in ULSD



Cost-effectiveness Study USA

Recent independent WTW study performed by TIAX:

For 2002:

- GTL fuels offer significant reductions in criteria pollutants
- Other gas-based fuels can achieve greater reductions (per vehicle), but the cost impact of using GTL fuels is significantly less
- GTL fuels are (several times) more cost-effective for reductions in criteria pollutants

For 2010:

- GTL fuels will continue to be the most cost-effective option for reductions in criteria pollutants from existing engines
- Emissions will be strictly controlled and all new engines will have similar emission levels, eliminating the environmental drivers for CNG / LPG
- But, after-treatment technologies are in the early stages of development and new emission limits may not be achievable (without “zero” sulfur diesel).

Good fit with draft strategy document (Assembly Bill 2076)
“California Strategy to reduce Petroleum Dependence”

Taking GTL advantages to Market

- What product is to be marketed ?
  - 100% GTL product
  - Blends of GTL in automotive diesel
- Key stakeholders
  - Governments and Regulators
  - OEMs
  - Consumer Groups
- Stakeholder engagement
  - Focused discussions
  - Collaborative field trials with stakeholders

Blends or 100% GTL ? -Properties & Benefits

Blend (20 – 30%) GTL

- Demonstrable emissions benefits
- No vehicle modification required
- Use existing diesel infrastucture
- Larger volumes of product available

…. but

- Emissions benefits could reduce as refinery diesel specs and engine technologies improve

Pure (100%) GTL

- Larger emissions benefits
- Minor vehicle modification required
- Use existing diesel infrastucture
- Technology enabler (e.g. advanced after-treatment)

…. and

- Potential for further benefits through engine developments in efficiency and other key areas.
- Bridge to renewable energy sources

Different Geographic drivers

- OECD – “zero sulphur” and advanced aftertreatment, benefits of 20-30% blends not clearcut. However, 100% could enable engine efficiency improvements
- Developing Countries – Serious concerns about urban air pollution, emissions benefits significant from 20-30% blends

Stakeholders

- Government and Regulators
  - US Department of Energy
    - Participation in DOE workshop (Oct 2002) on F-T diesel designation
    - Fulfils criteria pertinent to designate F-T diesel fuel as alternative fuel (under Sec. 301[2] of the Energy Policy Act of 1992)
  - EU Commission DG TREN (Directorate General Transport and Environment) Currently assessing alternative fuels
- OEMs
  - Collaborative studies on GTL, e.g Volkswagen, Bosch etc
- Consumer Groups
  - 100% GTL - Early targets commercial fleets, operating within city environs
    - Buses, Taxis, Light and heavy duty delivery vehicles etc
    - Home base refueling (not retail stations)
  - GTL blends – Premium diesel for private motorist
    - Demonstrable emissions benefit

GTL Fleet Trials in the US (1)

[1] California

Partners Yosemite Waters
DOE NREL
SCAQMD
Johnson Matthey
Shell
International Truck and Engine

Purpose

- Demonstrate that technologies are robust under real operating conditions
- Evaluate scientifically the emissions reductions that can be achieved
- To provide key data to legislators, commercial users and the public, for important air quality decisions and legislation

Timing Q1 2003 – Q2 2004

[2] CARB Certification for SMDS Gasoil

Participants California Air Resources Board
Southwest Research Institute
Shell

Timing Ongoing

GTL Fleet Trials in the US (2)

[3] California

Partners California Department of Transportation
Shell

Purpose Durability, compatibility

Key Findings

- No leaks of fuel from any of the vehicles –on changing to GTL & back again
- No increases in maintenance for any of the vehicles
- Fleet operator very happy with the performance of the fuel

Timing Completed 2002

[4] California

Partners Ralphs Grocery
ATL
SCAQMD & CEC
DOE NREL
Ricardo
Cummins
Cleaire
Shell

Purpose

- Similar to Yosemite water trial, but in engines modified to optimize combustion of GTL fuel.

- **Timing** Q4 2003 – Q3 2004

GTL Fleet Trials in Europe

[1] Berlin VW-Shell Trial

Participants Volkswagen
Shell

Timing May 2003 – Oct 2003

German Chancellor Gerhard Schröder launched the trial, part of a joint research & development programme looking at new road vehicle technologies and fuels.

[2] London Bus Trial

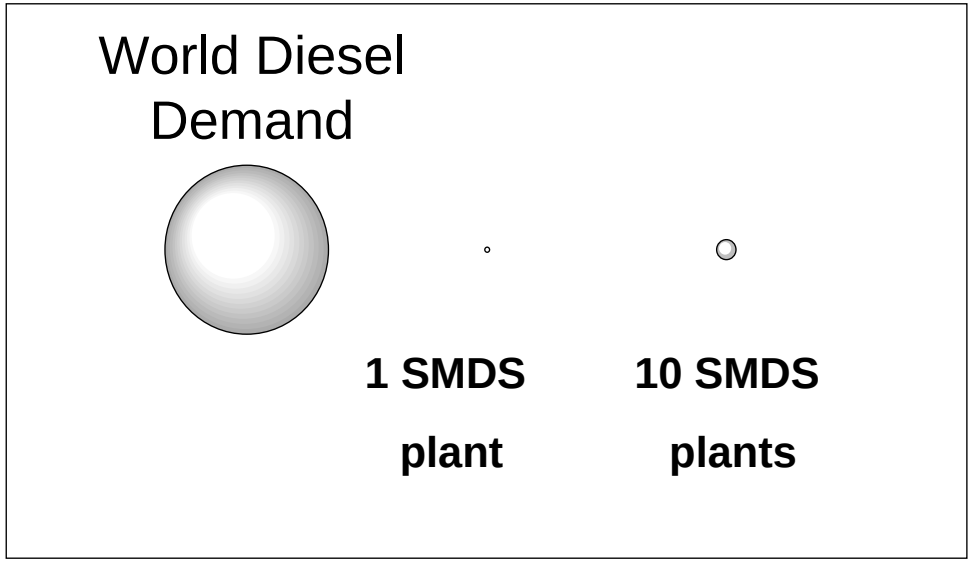
Participants London General
EvoBus (UK) Ltd
DaimlerChrysler
Shell

Timing July 2003 – Sept 2003

Trial of Shell GTL fuel launched by UK Green Fuels Minister David Jamieson MP on 8th of July, in cooperation with Daimler Chrysler and 'London General'.

The Future -GTL Gasoil production

Small globally…….



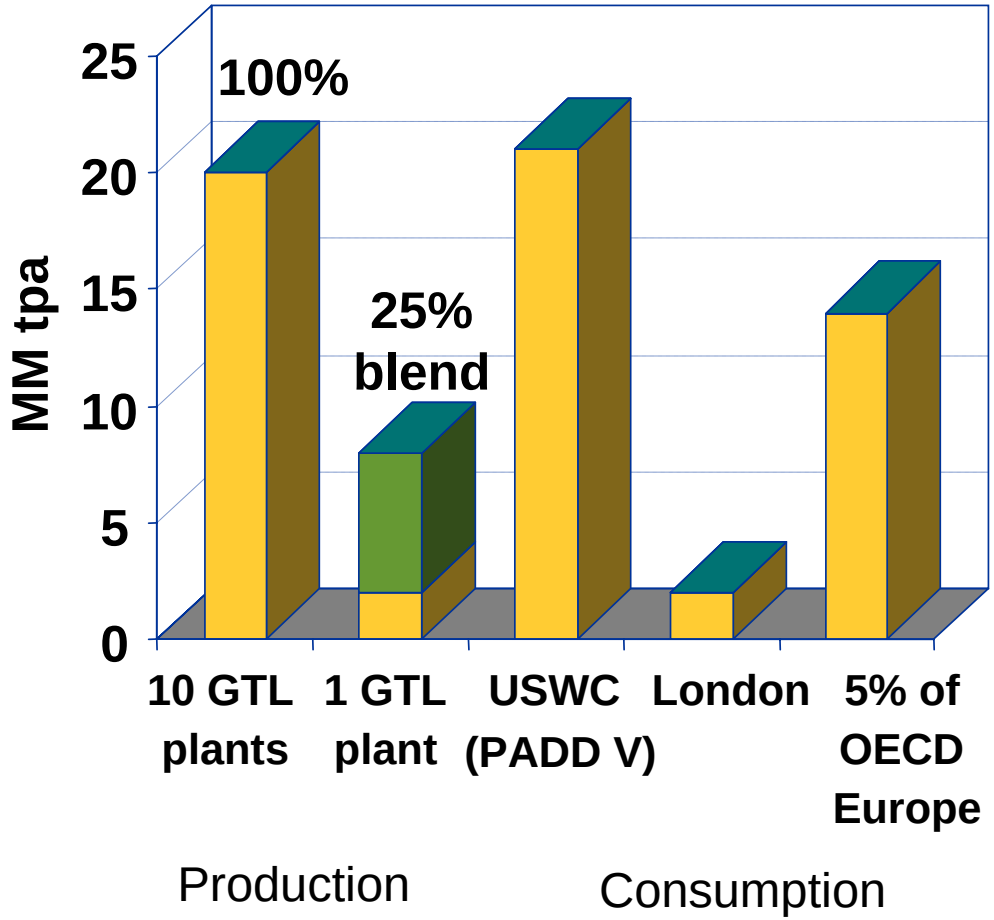
10 large scale GTL plants

- ~2.5% of world diesel demand, or
- Diesel demand of US West Coast

or

- ~8% of diesel demand of OECD Europe

But significant locally



The Future …but already present today at some retail sites

Shell Pura Diesel in Thailand

- A blend of normal diesel, Shell GTL and an additive package
- Product proposition
  - Engine clean-up
  - Reduced black smoke
- In Shell retail outlets at a price premium
- Launched in Bangkok in Jan 2002, went nationwide in Feb

Shell Diesel 2004 in Greece

- A blend also formulated using Shell GTL
- Product Proposition
  - Reduced black smoke in the taxi fleet in advance of the Olympics
- Launched in Athens in July 2003

Conclusions

- Gas to Liquids, an integral part of the Shell's future fuels strategy
- GTL is an essential component of the niche fuels scene
- Customer acceptance is key, but often overlooked
  - Advantages in keeping familiar vehicles and infrastructure
- GTL has advantages in several key areas
  - Energy diversification, Vehicles emissions, Infrastructure compatibility etc.
- Field trials are a good route to engage with stakeholders
  - Governments, OEMs, Consumer Groups